

I CLAIM:

1 1. A method for echo cancellation in a communication system utilizing a
2 bidirectional transmission medium, said method comprising the steps of:

3 (a) generating a first signal at a first signaling rate within a first frequency
4 band, said first signal characterized by an echo at said first signaling rate within said first
5 frequency band;

6 (b) transmitting said first signal in a first direction through said bidirectional
7 medium;

8 (c) receiving a second signal in a second direction through said bidirectional
9 medium at a second signaling rate within a second frequency band, said first and second
10 frequency bands being partially overlapped;

11 (d) canceling said echo from said second signal, said canceling step including
12 the step of replicating an echo within said second frequency band whereby said echo
13 canceling is performed within said second frequency band.

1 2. A method for echo cancellation in a communication system utilizing a
2 bidirectional transmission medium, said method including the steps of:

3 (a) transmitting a first signal in a first direction through said medium at a first
4 signaling rate within a corresponding first bandwidth, said first signal characterized by an

5 echo at said first signaling rate within said first bandwidth;

6 (b) receiving a second signal in a second direction through said medium at a
7 second signaling rate within a corresponding second bandwidth, such that said first and
8 second bandwidths are partially overlapped, said step of receiving said second signal further
9 comprising the steps of:

10 (i) filtering said second signal such that all transmit energy above a
11 Nyquist rate corresponding to said second signal is eliminated; and

12 (ii) sampling said second signal at a sampling rate that is equal to or
13 greater than said Nyquist rate for said second signal;

14 (c) canceling said echo from said second signal, said canceling step
15 comprising the steps of:

16 (i) converting said first signal into a signal having a sampling rate less
17 than a Nyquist sampling rate for said first signal, but equal to said sampling rate for said
18 second signal;

19 (ii) replicating an echo signal at a sampling rate equal to said sampling
20 rate for said second signal; and

21 (iii) subtracting said replicated echo signal from said second signal;
22 whereby said echo canceling is performed within said second bandwidth.

1 3. A method for echo cancellation in a communication system utilizing a

2 bidirectional transmission medium and transmitting information at symmetrical information
3 rates, said method including the steps of:

4 (a) transmitting a first signal in a first direction through said medium at a first
5 signaling rate within a corresponding first bandwidth, said first signal characterized by an
6 echo at said first signaling rate within said first bandwidth;

7 (b) receiving a second signal in a second direction through said medium at a
8 second signaling rate within a corresponding second bandwidth, such that said first and
9 second bandwidths are partially overlapped, said step of receiving said second signal further
10 comprising the steps of:

11 (i) filtering said second signal such that all transmit energy above a
12 Nyquist rate corresponding to said second signal is eliminated; and

13 (ii) sampling said second signal at a sampling rate that is equal to or
14 greater than a Nyquist rate for said second signal; and

15 (c) canceling said echo from said second signal, said canceling step further
16 comprising the steps of:

17 (i) converting said first signal into a signal having a sampling rate less
18 than a Nyquist sampling rate for said first signal, but equal to said sampling rate for said
19 second signal;

20 (ii) replicating an echo signal at a sampling rate equal to said sampling
21 rate for said second signal; and,

22 (iii) subtracting said replicated echo signal from said second signal;
23 whereby said echo canceling is performed within said second bandwidth.

1 4. A method for echo cancellation in a communication system utilizing a
2 bidirectional transmission medium and transmitting information at symmetrical information
3 rates, said method including the steps of:

4 (a) transmitting a first signal in a first direction through said medium at a first
5 baud rate within a corresponding first bandwidth, said first signal characterized by an echo
6 at said first baud rate within said first bandwidth, said step of transmitting said first signal
7 further comprising the steps of:

8 (i) sampling said first signal at fractionally-spaced intervals;
9 (ii) shaping said sampled signal;
10 (iii) converting said shaped signal to an analog transmit signal at a
11 transmit sampling rate;

12 (iv) filtering said analog transmit signal; and

13 (v) transmitting said filtered analog transmit signal through a
14 directional coupler to said medium;

15 (b) receiving a second signal in a second direction through said medium at a
16 second baud rate within a corresponding second bandwidth, such that said first and second
17 bandwidths are partially overlapped, said step of receiving said second signal further

18 comprising the steps of:

19 (i) receiving said second signal through a directional coupler;
20 (ii) filtering said second signal;
21 (iii) converting said filtered second signal into a digital signal
22 representative of said second signal and characterized by a sampling rate that is equal to or
23 greater than a Nyquist rate for said second signal; and;

24 (c) canceling said echo from said second signal, said canceling step
25 comprising the steps of:

26 (i) converting said first signal into a signal having a sampling rate less
27 than a Nyquist sampling rate for said first signal, but equal to said sampling rate for said
28 second signal;

29 (ii) replicating an echo signal at a sampling rate equal to said sampling
30 rate for said second signal; and,

31 (iii) subtracting said replicated echo signal from said digital signal
32 representative of said second signal;

33 whereby said echo canceling is performed within said second bandwidth

1 5. A method for echo cancellation in a communication system utilizing a
2 bidirectional transmission medium and transmitting information at symmetrical information
3 rates, said method including the steps of:

4 (a) transmitting a first signal in a first direction through said medium at a first
5 baud rate within a corresponding first bandwidth, said first signal characterized by an echo
6 at said first baud rate within said first bandwidth, said step of transmitting said first signal
7 further comprising the steps of:

- 8 (i) sampling said first signal at fractionally-spaced intervals;
- 9 (ii) shaping said sampled signal;
- 10 (iii) modulating said shaped, signal;
- 11 (iv) converting said modulated signal to an analog transmit signal at
12 a transmit sampling rate;
- 13 (v) filtering said analog transmit signal; and
- 14 (vi) transmitting said filtered analog transmit signal through a
15 directional coupler to said medium;

16 (b) receiving a second signal in a second direction through said medium at a
17 second baud rate within a corresponding second bandwidth, such that said first and second
18 bandwidths are partially overlapped, said step of receiving said second signal further
19 comprising the steps of:

- 20 (i) receiving said second signal through a directional coupler;
- 21 (ii) filtering said second signal;
- 22 (iii) converting said filtered second signal into a digital signal
23 representative of said second signal and characterized by a sampling rate that is equal to or

greater than a Nyquist rate for said second signal; and;

(c) canceling said echo from said second signal, said canceling step comprising the steps of:

(i) converting said first signal into a signal having a sampling rate less than a Nyquist sampling rate for said first signal, but equal to said sampling rate for said second signal;

(ii) replicating an echo signal at a sampling rate equal to said sampling rate for said second signal; and,

(iii) subtracting said replicated echo signal from said digital signal representative of said second signal;

whereby said echo canceling is performed within said second bandwidth

6. An apparatus for echo cancellation in a communication system utilizing a bidirectional transmission medium, said apparatus comprising:

(a) an information source for generating a first signal at a first signaling rate within a first frequency band, said first signal characterized by an echo at said first signaling rate within said first frequency band;

(b) a transmitter for transmitting said first signal in a first direction through said bidirectional medium;

(c) a receiver for receiving a second signal in a second direction through said

9 medium at a second signaling rate within a second frequency band, said first and second
10 frequency bands being partially overlapped;

11 (d) an echo canceler for canceling said echo from said second signal, said
12 canceler comprising an echo replica unit for replicating an echo within said second frequency
13 band the combination being so constructed and arranged that said canceling is performed
14 within said second frequency band.

1 7. An apparatus for echo cancellation in a communication system utilizing
2 a bidirectional transmission medium, said apparatus including:

3 (a) a transmitter for transmitting a first signal in a first direction through said
4 medium at a first signaling rate within a corresponding first bandwidth, said first signal
5 characterized by an echo at said first signaling rate within said first bandwidth;

6 (b) a receiver for receiving a second signal in a second direction through said
7 medium at a second signaling rate within a corresponding second bandwidth, such that said
8 first and second bandwidths are partially overlapped, said receiver further comprising:

9 (i) an analog filter for filtering said second signal, such that all
10 transmit energy above a Nyquist rate corresponding to said second signal is eliminated; and,

11 (ii) an analog-to-digital converter for sampling said second signal, at
12 a sampling rate that is equal to or greater than said Nyquist rate for said second signal; and,

13 (c) an echo canceler for canceling said echo from said second signal, said echo

canceler comprising:

(i) a sampler for sampling said first signal at fractionally-spaced intervals to convert said first signal into a signal having a sampling rate less than a Nyquist sampling rate for said first signal, but equal to said sampling rate for said second signal;

(ii) an echo replica unit for replicating an echo signal at a sampling rate equal to said sampling rate for said second signal; and,

(iii) an algebraic adder circuit for subtracting said replicated echo signal from said second signal;

the combination being so constructed and arranged that said echo canceling is performed within said second bandwidth.

8. An apparatus for echo cancellation in a communication system utilizing a bidirectional transmission medium and transmitting information at symmetrical information rates, said apparatus comprising:

(a) a transmitter for transmitting a first signal in a first direction through said medium at a first signaling rate within a corresponding first bandwidth, said first signal characterized by an echo at said first signaling rate within said first bandwidth;

(b) a receiver for receiving a second signal in a second direction through said medium at a second signaling rate within a corresponding second bandwidth, such that said first and second bandwidths are partially overlapped, said receiver further including:

10 (i) an analog filter for filtering said second signal such that all transmit
11 energy above a Nyquist rate corresponding to said second signal is eliminated;

12 (ii) an analog-to-digital converter for sampling said second signal at
13 a sampling rate that is equal to or greater than a Nyquist rate for said second signal; and,

14 (c) an echo canceler for canceling said echo from said second signal, said echo
15 canceler comprising:

16 (i) a sampler for sampling said first signal at fractionally-spaced
17 intervals to convert said first signal into a signal having a sampling rate less than a Nyquist
18 sampling rate for said first signal, but equal to said sampling rate for said second signal;

19 (ii) an echo replica unit for replicating an echo signal at a sampling
20 rate equal to said sampling rate for said second signal; and,

21 (iii) an algebraic adder circuit for subtracting said replicated echo
22 signal from said second signal;

23 the combination being so constructed and arranged that said echo canceling is performed
24 within said second bandwidth.

1 9. An apparatus for echo cancellation in a communication system utilizing
2 a bidirectional transmission medium and transmitting information at symmetrical
3 information rates, said apparatus comprising:

4 (a) a transmitter for transmitting a first signal in a first direction through said

5 medium at a first baud rate within a corresponding first bandwidth, said first signal
6 characterized by an echo at said first baud rate within said first bandwidth, said transmitter
7 further comprising:

8 (i) a sampler for sampling said first signal at fractionally-spaced
9 intervals;

10 (ii) a shaping filter for shaping said sampled signal;

11 (iii) a digital-to-analog converter for converting said shaped signal to
12 an analog transmit signal at a transmit sampling rate;

13 (iv) a transmit analog filter for filtering said analog transmit signal;

14 (v) a directional coupler;

15 (b) a receiver for receiving a second signal in a second direction through said
16 medium at a second baud rate within a corresponding second bandwidth such that said first
17 and second bandwidths are partially overlapped, said receiver including:

18 (i) a directional coupler;

19 (ii) a receive analog filter for filtering said second signal; and

20 (iii) an analog-to-digital converter for converting said second signal
21 into a digital signal representative of said second signal; and

22 (c) an echo canceler for canceling said echo from said second signal, said echo
23 canceler comprising:

24 (i) a sampler for sampling said first signal at fractionally-spaced

intervals to convert said first signal into a signal having a sampling rate less than a Nyquist sampling rate for said first signal, but equal to said sampling rate for said second signal;

(ii) an echo replica unit for replicating an echo signal at a sampling rate equal to said sampling rate for said second signal; and

(iii) an algebraic adder circuit for subtracting said replicated echo signal from said digital signal;

the combination being so constructed and arranged that said echo canceling is performed within said second bandwidth.

10. An apparatus for echo cancellation in a communication system utilizing a bidirectional transmission medium and transmitting information at symmetrical information rates, said apparatus comprising:

(a) a transmitter for transmitting a first signal in a first direction through said medium at a first baud rate within a corresponding first bandwidth, said first signal characterized by an echo at said first baud rate within said first bandwidth, said transmitter further comprising:

(i) a sampler for sampling said first signal at fractionally-spaced intervals;

(ii) a shaping filter for shaping said sampled signal;

(iii) a modulator for modulating said shaped signal;

12 (iv) a digital-to-analog converter for converting said modulated signal
13 to an analog transmit signal at a transmit sampling rate;

14 (v) a transmit analog filter for filtering said analog transmit signal;

15 (vi) a directional coupler;

16 (b) a receiver for receiving a second signal in a second direction through said
17 medium at a second baud rate within a corresponding second bandwidth such that said first
18 and second bandwidths are partially overlapped, said receiver including:

19 (i) a directional coupler;

20 (ii) a receive analog filter for filtering said second signal; and

21 (iii) an analog-to-digital converter for converting said second signal
22 into a digital signal representative of said second signal; and

23 (c) an echo canceler for canceling said echo from said second signal, said echo
24 canceler comprising:

25 (i) a sampler for sampling said first signal at fractionally-spaced
26 intervals to convert said first signal into a signal having a sampling rate less than a Nyquist
27 sampling rate for said first signal, but equal to said sampling rate for said second signal;

28 (ii) an echo replica unit for replicating an echo signal at a sampling
29 rate equal to said sampling rate for said second signal; and

30 (iii) an algebraic adder circuit for subtracting said replicated echo
31 signal from said digital signal;

32 the combination being so constructed and arranged that said echo canceling is performed
33 within said second bandwidth.